The Role of Demand Models in Market Analyses

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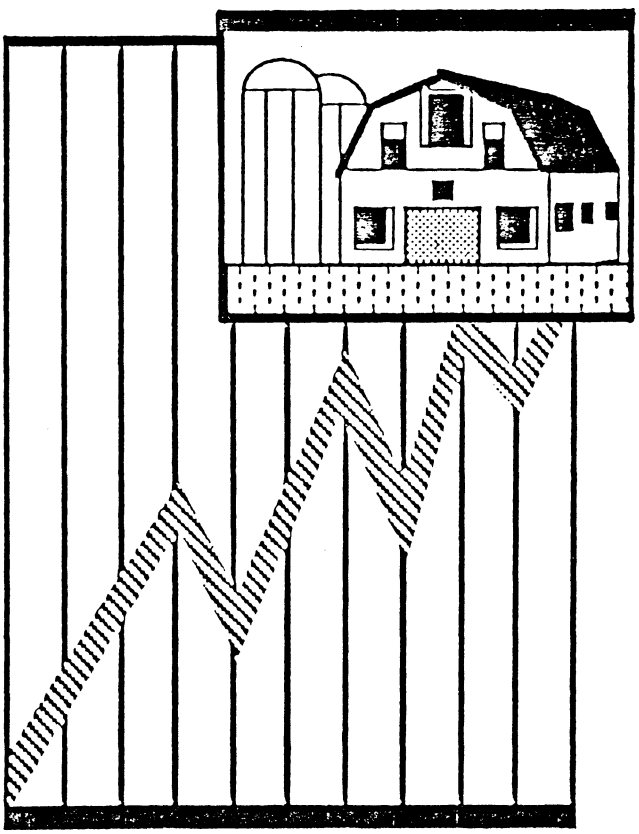

Concept Paper
Farm Income Enhancement Program
April 1989

This material is based upon work supported by the U.S. Department of Agriculture, Cooperative State Research Service, under Agreement No. 88-34182-3960.

THE ROLE OF DEMAND MODELS IN MARKET ANALYSES

A Concept Paper
for
The Farm Income Enhancement Program

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The author is grateful to Eugene Jones, Mario J. Miranda, and Gary D. Schnitkey for their helpful comments on an earlier draft of this paper.

INTRODUCTION

The pattern of consumer demand for goods and services may undergo dramatic changes over time. These changes can be detected by examining the historical trends of aggregate and per capita demands for various groups of goods and services. There are, of course, many factors contributing to changes in consumer demand. At the aggregate level, demand may grow simply because of increases in population and income. Changes in per capita demand may result from changes in income, prices and other demographic factors. The task of modeling consumer demand is to identify those factors which can effectively explain the changes in aggregate demand and/or per capita or per household demand.

The analysis of consumer demand deals with goods and services purchased directly by consumers and households. These consumer goods are final products that are often considerably different from raw materials produced in the agricultural sector. A case in point is the soybean which is one of the most important cash crops in Ohio. Consumers generally do not purchase soybeans and consume them directly. Figure 1 shows how soybeans flow through the processing and marketing channels before they become part of the final consumer food products such as margarine or potato chips. In fact, few consumers know that soybean oil is used in potato chips that they purchase in the supermarket. Nevertheless, consumers are aware that potato chips use frying oils and fats as necessary ingredients. Also, some consumers know that soybean oil contains less saturated fats than other oils. Therefore, the more potato chips we purchase, the more oils and fats will be needed to fry them.

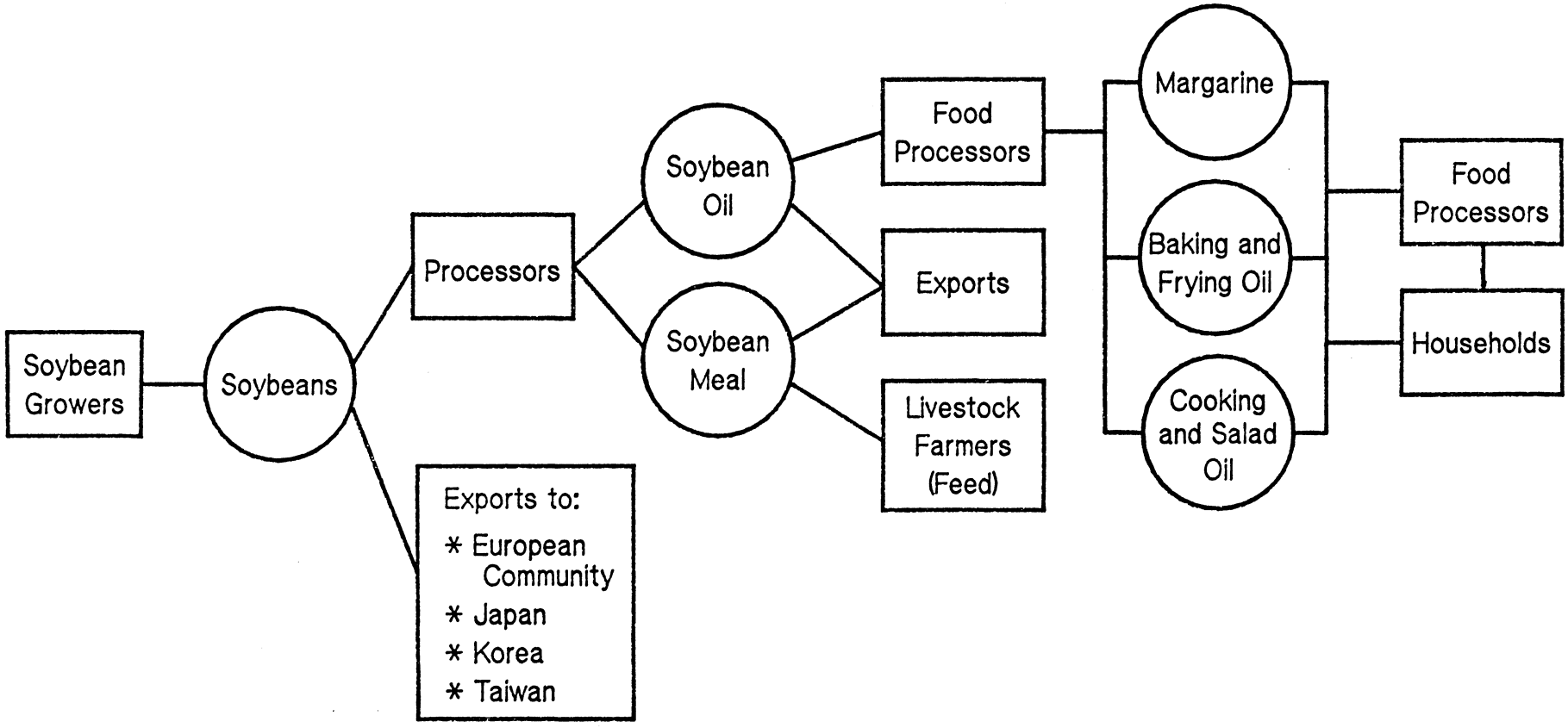

Figure 1. Market Structure of Soybeans

Because of the low saturated fat in soybean oil, it seems reasonable to postulate that more soybean oil will be demanded.

In order to understand the market forces affecting the demand for soybeans, we need to know the factors affecting the demand for various food products which use soybean products. The relationships between consumer demand and the demand for an agricultural commodity at the farm gate are often complex. One of the objectives of this paper is to discuss the role of demand models in the market analysis for agricultural commodities. In particular, we will address how we link the consumer demand to the demand for agricultural commodities at the farm gate. In addition, we will discuss the methodologies for analyzing structural changes in demand, for analyzing the demand for new food products, and for analyzing the potential for expanding the market for existing commodities.

Our basic premise is that understanding the consumer demand will enable us to better predict future demand for new and existing products. The demand for a particular product may be expanded through changes in such factors as prices, advertising and promotion, and the consumer's recognition of the desirable characteristics of a product. This and other economic concepts will be illustrated using soybeans as a case study. The paper concludes with several specific recommendations for implementing the proposed demand analyses so as to enhance farm income in Ohio.

DEMAND AND MARKET ANALYSIS

Let us look at Figure 1 again. This diagram shows the detailed marketing and processing channels for soybeans. Soybeans are grown by farmers in many states in the U.S. They may be directly exported to other

countries (about 45% of the crop) or crushed to produce meal and oil (about 55%). Both meal and oil have domestic and foreign markets. Soybean oil has three primary end uses, namely, for making margarine, and the uses as baking/frying oil and cooking/salad oil. Furthermore, consumer soybean products may be margarine or cooking oil. They also include such products as potato chips or cookies which are processed with soybean oil. Even though the demand for potato chips and cookies will affect the demand for soybean oil, data limitations would prevent us from attempting to analyze the demands for these processed food items in order to assess their effects on the demand for soybean oil.

There are three distinctive areas of competition related to soybean production and consumption. The first deals with the competition on the supply side. Regional competitions in soybean production exist between Ohio soybean growers and growers in other states. In 1988, Ohio growers harvested 3.7 million acres of soybeans, which accounted for 6.5% of the total U.S. soybean acreage (1).

Are soybeans produced in Ohio different from those produced in other states? We compare the soybean prices received by farmers in Ohio and the U.S. shown in Figure 2 (2,3). The two price series are almost identical. Since soybeans have a market reflecting most closely a competitive market, the same prices between Ohio and U.S. soybeans suggest that there are no significant quality differences between soybean produced in Ohio and those produced elsewhere. Figure 2 also shows that soybean prices fluctuated greatly during 1970's and 1980's. Soybean acreage and total farm receipts in Ohio also fluctuated greatly during this period (1,3). The competitive position of Ohio's soybean growers is determined by their ability to

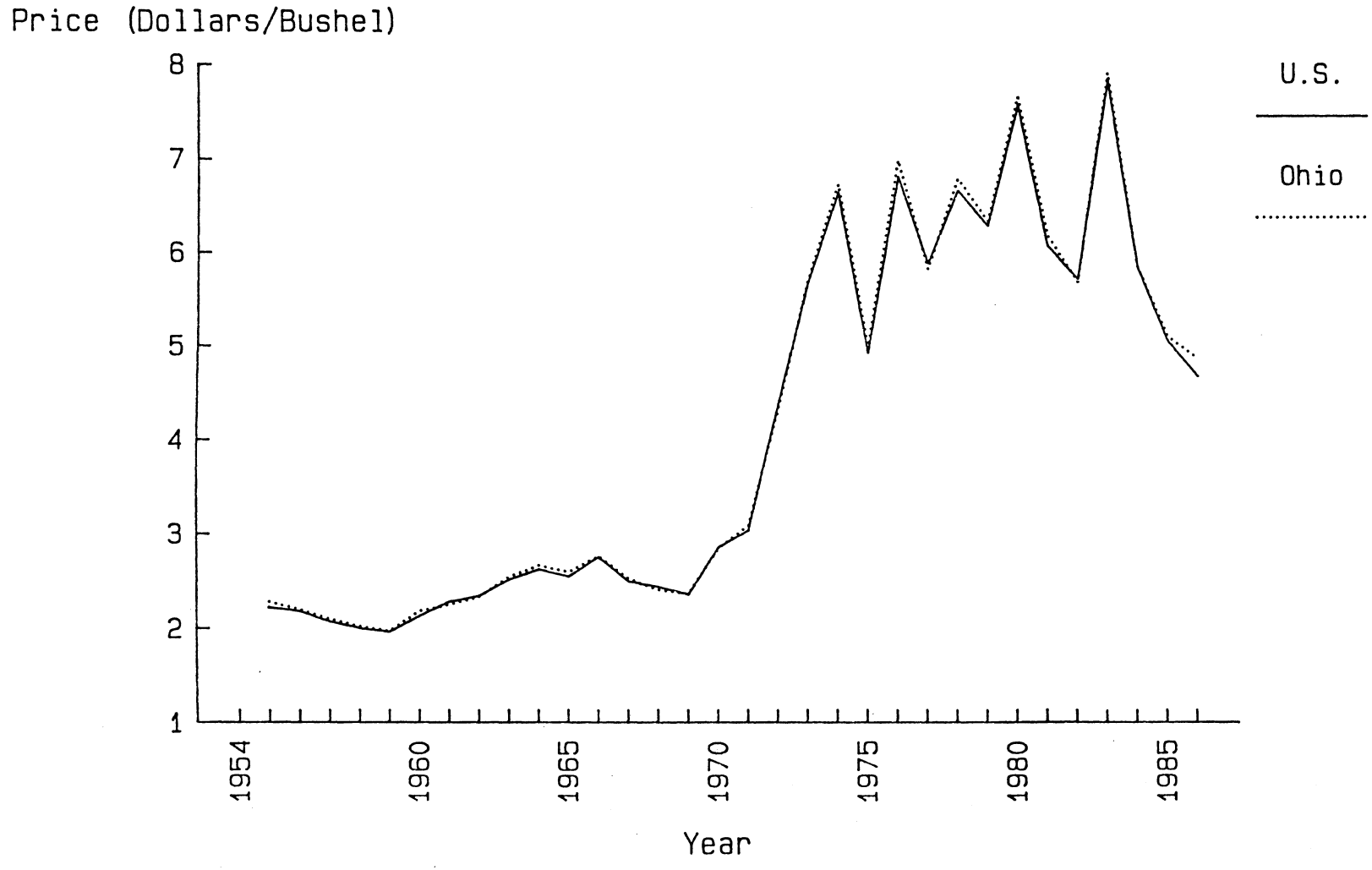

Figure 2. Soybean Prices in Ohio and the U.S., 1955–86.

produce this crop at a lower cost than growers elsewhere. In order to understand this supply competition, we need to know the supply responses in Ohio and other states or regions.

The second area of competition occurs at the stage of final consumption. In the case of soybean, the most fruitful approach to analyze this competition is to model a complete demand system for fats and oils by end uses. As pointed out earlier, there are three major end uses: (A) margarine, (B) baking and frying oils, and (C) cooking and salad oils. Table 1 shows the three groups of major fats and oils and the U.S. consumption figures for selected years during the period of 1950-1986. Soybean oil is important in all categories of end use. During this 36 years period, soybean oil has steadily increased its market share in all cases. Considering Group A, butter is relevant because it has been competing with margarine. The data clearly show that the margarine produced by soybean oil has out competed butter. A demand model is most useful for analyzing this competition. The purpose of a demand model is to identify the demand factors and their quantitative impacts on the demand for a commodity such as soybean oil. Note that we can not handle one commodity in isolation because of its relationships with other closely related commodities (they may be substitutes or complements). Therefore, we need a complete demand system in order to investigate fully these substitution and complementary relationships.

As a starting point, one usually relies on a Marshallian demand system in which a commodity demand (measured by quantity, expenditure, or expenditure share) is expressed as a function of income and prices. Marshallian demand theory maintains that the increasing trend in soybean

Table 1
Domestic Consumption of Edible Fats and Oils by End Uses
(Million Pounds)

Group A: Butter and Fats and Oils Used for Margarine

Year	Butter	Corn	Cottonseed	Lard	Soybean
1950	1,648	0	322	5	312
1955	1,537	0	286	27	746
1960	1,382	82	158	58	1,105
1965	1,292	155	119	67	1,241
1970	1,106	188	64	154	1,381
1975	1,021	212	49	16	1,691
1980	1,017	217	26	70	1,666
1985	1,164	200	52	59	1,735
1986	1,114	248	36	22	1,661

Group B: Baking and Frying Fats and Oils

Year	Coconut	Cottonseed	Lard	Palm	Soybean	Tallow
1950	0	356	201	0	841	24
1955	4	354	403	0	930	129
1960	10	380	497	0	1,169	333
1965	35	438	477	24	1,739	460
1970	53	194	509	143	2,077	496
1975	128	131	140	699	2,416	431
1980	123	132	328	215	2,675	730
1984	100	156	274	226	3,655	942
1985	122	202	299	304	3,440	1,016
1986	116	135	222	247	3,359	905

Group C: Cooking and Salad Fats and Oils

Year	Corn	Cottonseed	Groundnut	Lard	Soybean
1950	224	399	54	1,892	393
1955	243	611	15	1,631	633
1960	224	775	58	1,399	710
1965	236	801	103	1,115	1,200
1970	202	479	156	952	2,288
1975	297	207	150	608	3,274
1980	408	382	105	474	4,226
1984	511	399	118	0	4,800
1985	524	373	137	0	4,686
1986	491	408	151	0	5,054

Sources: 4,5,6,7,8.

oil consumption and the decreasing trend in butter consumption over the period of 1950-1986 is due to either changes in income, or relative prices or both. Recent modeling of the demand system for edible fats and oils by Chern et al. (9,10) sheds some insights on these trends. Our preliminary research results show that these opposite trends are best explained by changes in the relative prices between butter and soybean oil. There has not been positive income effects for soybean oil used in margarine production. In fact, our study showed that butter continues to be perceived as a superior good (i.e., with a stronger income effect) to soybean oil for margarine production. These conclusions are consistent with historical price trends shown in Figure 3. During 1950-1986, butter was always more expensive than soybean oil on a per pound basis. The price difference widened substantially after 1974. Therefore, the relative price between butter and soybean oil has been increasing in favor of the consumption of soybean oil used for making margarine.

It is important to point out that not all fats and oils are competing with each other. Our research has found a complementary relationship among fats and oils. For example, soybean oil and corn oil are found to be substitutes in Group A, but complements in Group C. Also, soybean oil and lard are found to be complements in Groups A and B.

The third area of competition is in the export market. There are two elements of competition for U.S. soybeans. In the first place, soybean oil will compete with other edible fats and oil in a foreign market such as in Taiwan or Japan, very much the same way as it does in the domestic market. We need a demand model to analyze this type of competition as previously discussed. The second element is the competition among

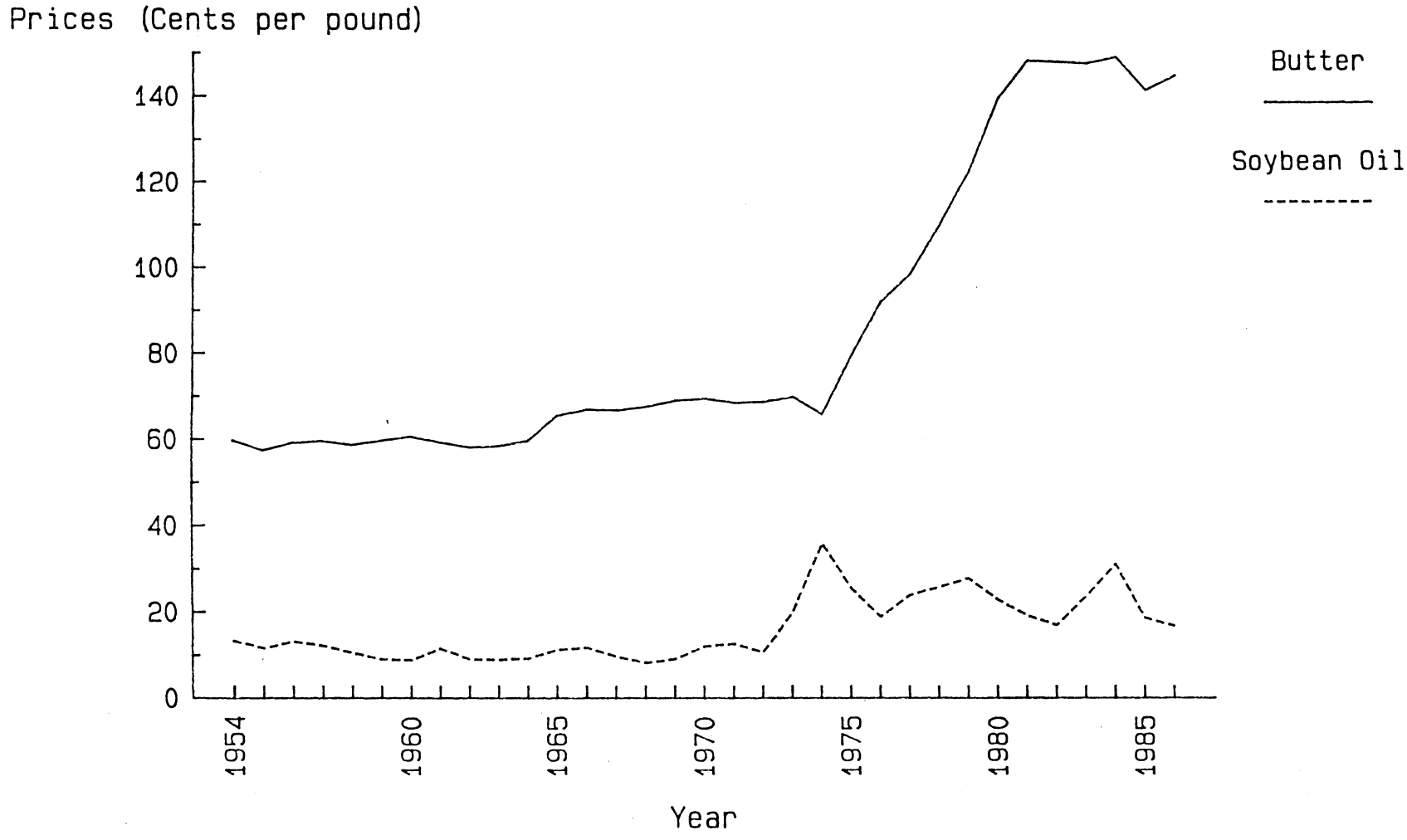

Figure 3. Prices of Soybean Oil and Butter, 1954–86.

suppliers in the export market. Soybean producers in the U.S. face competition in the export markets from two major competitors: Argentina and Brazil. Competition among these competitors can be analyzed by integrating the forces of supply into our demand system.

The preceding discussion reveals that the demand analysis is only one part of the market analysis. The three areas of competition represent various market forces affecting the soybean sector. There exists no easy way to quantify the effects of changes in the demand for a consumer product such as margarine on the demand for soybeans produced in Ohio. We need to integrate these three areas of competition and other related economic relationships characterizing the performance of the soybean sector.

There are two previous major studies attempting to model these supply and demand relationships for the U.S. soybean sector. The first major soybean model was developed by Houck et al. (11). This is a dynamic model which contains more than 30 equations. The second major soybean model was developed by Williams (12). His model contains 32 equations related to demand and supply in both the domestic and foreign markets. Both of these models incorporated the demand component in a very aggregate fashion. No complete demand system was estimated in these models. Further research is needed to incorporate the complete demand systems for edible fats and oils into a comprehensive model for the soybean sector.

IMPACTS OF HEALTH CONCERNS ON DEMAND

Recently, agricultural economists have had increasing interests in investigating the structural changes in food demand resulting from

consumers' health concern about food consumption. A structural change occurs when changes in demand can not be plausibly explained by changes in such conventional demand factors as income and prices. One of the most important factors causing these structural changes are changes in tastes and preferences. The increasing recognition of the impacts of diets on health has been frequently cited as an important reason for these preference changes. There are two most important examples of the possible impacts of health concern on food demand. The first is the increasing consumption trend of vegetable oil products (such as margarine and soybean oil) vs the decreasing consumption trend of the animal fat products (such as butter and lard). The second example is the increasing consumption trend of chicken and seafood vs the decreasing consumption trend of red meats. In both of these example, the health concern is about the intake of fats, particularly, the saturated fats which have been found to increase the risk of causing cardiovascular diseases. Whether these health concerns have caused a shift of consumer preference has important implications for marketing strategies for food commodities. If the changes in the consumption trend are caused by changes in relative prices, then they can be reversed by changing relative prices through improved production efficiency. The changing trends would be much more difficult to reverse if they are caused by health concerns. Furthermore, the different causes would also require different promotion and advertising strategies to increase demand.

Consider further the case of fats and oils. Table 2 shows the proportion of fatty acids in the nine major products. Clearly, butter, coconut oil, lard, palm oil, and tallow contain a relatively higher

Table 2
Proportion of Fatty Acids in Fats and Oils

	Saturated Fatty Acids (%)	Monounsaturated Fatty Acids (%)	Polyunsaturated Fatty Acids (%)
Butterfat	66	30	4
Coconut Oil	92	6	2
Corn Oil	13	25	62
Cottonseed Oil	27	19	54
Groundnut Oil	18	48	34
Lard	41	47	12
Palm Oil	51	47	10
Soybean Oil	15	24	61
Tallow	52	44	4

Source: Bunch and Hazera (14).

proportion of saturated fats than other vegetable oils. Soybean oil has the least proportion of saturated fats. A health conscious consumer should prefer soybean oil over other fats and oils containing higher saturated fats. Has the health concern caused the structural changes in the demand for fats and oils in favor of vegetable oils during the last 20 or 30 years?

A nonparametric approach was used to analyze this question. The nonparametric analysis of consumer behavior was recently developed by Varian (13). This methodology is based on revealed preference theory. The theory states that our preferences are revealed by the commodity bundles we purchase in the marketplace under prevailing prices. If the structure of demand is stable, our purchased quantities and the associated prices for all the goods and services in the demand system should not violate the condition of the revealed preference theory. According to Varian, if the data (quantities and prices) satisfy the Generalized Axiom of Revealed Preference (GARP), there exists a well specified utility function that rationalizes the data.

We employed Varian's nonparametric method to examine the stability of the demand structure for the three groups of fats and oils specified earlier. Our research reveals several findings. First, lard is found to cause violations of GARP in Group C during the sample period (1950-1986). That is, if lard is included in the demand system, the demand structure becomes unstable. However, if lard is excluded, then the structure is relatively stable. This is a very important finding because it confirms the hypothesis that health concerns have led to structural changes in the demand for edible fats and oils. The test results also reveal that the

impacts of these health concerns are primarily on the end use for cooking and salad fats and oils. The impacts are much less significant on the uses for baking and frying fats and oils. It is important to further examine the implications of these findings.

Let us examine the historical trends of consumption for Group C (see Table 1). The consumption of lard has dropped from the number one position in 1950's to a negligible amount of consumption in 1980's. Lard has been replaced by soybean oil, corn oil and groundnut oil. Therefore, if the health concern caused the structural changes in the demand for fats and oil in this end use category, these changes definitely benefited soybean growers during this period.

Note that these research results are only preliminary. Much work needs to be done to understand more fully the consumer's perception of health risks and how this perception affects their food consumption patterns. With respect to methodology, we need to develop a framework to incorporate the health concerns in terms of either perception or information into the demand system so that we can quantify their impacts on the demand for a particular commodity like soybean oil. More importantly, the benefits to soybean growers resulting from the consumer's concern about saturated fats are far from certain. The increasing health concerns may, in fact, not just cause the substitution for vegetable oils but also reduce the overall demand for fats and oils. Should the latter occur, the demand for every vegetable oil will suffer a negative effect.

DEMAND FOR NEW PRODUCTS

One way to expand the demand for agricultural commodities is to develop new consumer products using these primary commodities. However, there are always risks and uncertainties in marketing new products. The success of any new product depends critically upon the acceptance of consumers. Even though advertising and promotion can persuade consumers to accept the new product, a long lasting market penetration depends upon whether or not the product satisfy the consumer's taste and preference. It is therefore essential to know what the consumer wants.

The characteristics model developed by Lancaster (15,16) can be used to analyze the demand for new goods. Lancaster argued that goods are consumed for their characteristics. For example, food products are consumed for their nutrients and flavor. His theory assumes that goods possess some common characteristics and the consumer draws utility or satisfaction from these charactertistics. Therefore, one can maintain a certain level of satisfaction with different combinations of these characteristics as may be traced by the so-called indifference curve used by economists. Given the budget, one can determine the efficient frontier which represents the feasible set of total units of various characteristics attainable under the budget. The consumer will determine how much of various goods to purchase in order to maximize his or her utility.

Figure 4 shows the basic idea of the Lancaster's model. This example consider two goods -- butter and margarine. Even though margarine is not a new good today, it was 20 years ago. One may wonder how margarine could successfully penetrate into the market. Let us consider only two

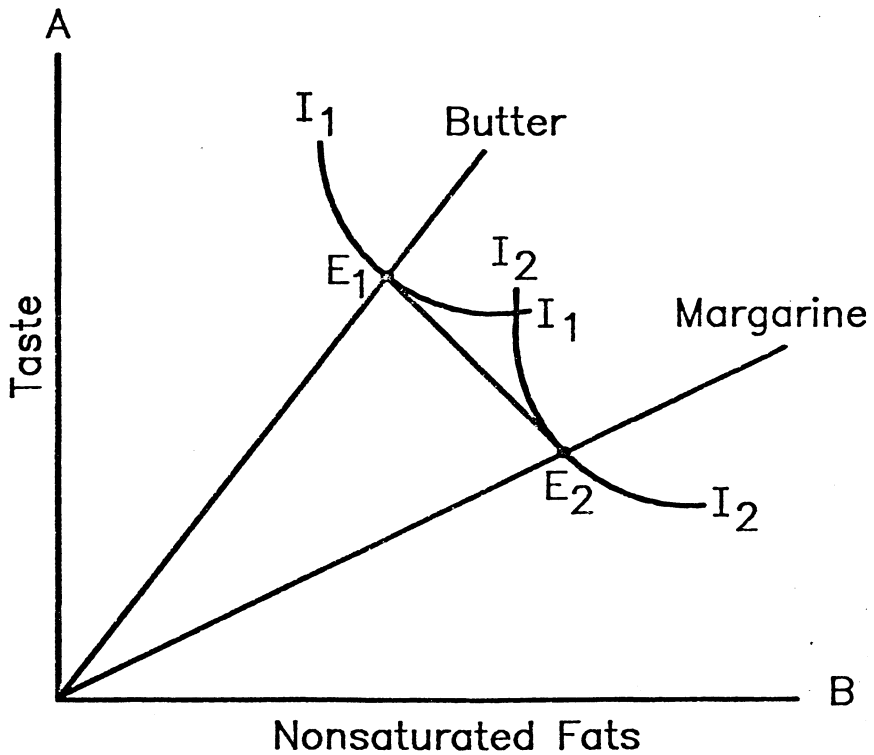

Figure 4. Lancaster's Characteristics Model

characteristics for butter and margarine: nonsaturated fats and taste. Margarine contains more nonsaturated fats and less taste than butter. Suppose there are two consumers (1 and 2) with an identical budget. In Figure 4, E_1E_2 is the efficient frontier for the budget. The curve I_1I_1 is the indifference curve for Consumer 1, while I_2I_2 is the indifference curve for Consumer 2. These preference structures indicate that Consumer 2 is more health conscious than Consumer 1 because he prefers more nonsaturated fats (relative to saturated fats). Consumer 1 prefers the flavor of butter. At the equilibrium condition (utility maximization), Consumer 1 would choose butter while Consumer 2 would choose margarine. This model demonstrates that if we can increase the number of consumers with the same preference as Consumer 2, then we can increase the demand for margarine. This theory may explain the dramatic increases in margarine consumption during 1970's and 1980's.

The preceding analysis shows that in order to apply the Lancaster's model to analyze the demand for new goods, we need information about the characteristics important to consumers and their perception of these characteristics. Of course, the nutrition and fat contents of margarine are always the same. The important thing is that the consumers' awareness and their perceived value or risks associated with these characteristics have been changing over time. It is this perception of value or risk that affects their consumption behavior. How can we obtain the needed data? The establishment of a consumer panel will facilitate the collection of the information necessary for these types of analysis.

KNOWING OUR FOREIGN CUSTOMERS

Agricultural commodities produced in Ohio `ave a worldwide market. As mentioned earlier, more than 45% of U.S. soybeans are exported to other countries. Thus a substantial portion of our customers are foreigners. The future of the U.S. agriculture depends critically upon these foreign markets. It seems intuitive that maintaining and expanding the foreign markets would strengthen the demand for our agricultural products and thus enhance farm income. It is therefore important to assess the subtainability and expansion opportunities of these foreign markets. As a starting point for this assessment, we should understand how these products are used in final consumption. The patterns of consumption are likely to be different among countries. For example, in the U.S., a substantial quantity of soybeans are used for making margarine. As discussed earlier, the competitive product for margarine is butter. In Taiwan, soybeans are used to make soysauce, soyflour, soymilk and tofu (bean curd), in addition to the major use of cooking oil. The competing goods for these soybean products are different. For example, for soymilk, they are milk and rice. The food consumption patterns are changing rapidly in countries like Taiwan, Japan, and South Korea, and these these countries import substantial agricultural commodities from the U.S. We need to know the demand parameters in these countries. Specifically, it is important to quantify the responses of demand in these countries to changes in price and income as well as the pattern of substitution among competing products.

Table 3 shows the quantities and values of imported corns and soybeans in Taiwan. The U.S. has dominated this market for the last 10

Table 3. Quantity and Value of Imports of Corns and Soybeans in Taiwan.

Year	Corn[a]		Soybeans[b]	
	Quantity (Thousand Tons)	Value (Million-U.S. Dollars)	Quantity (Thousand Tons)	Value (Million-US Dollars)
1978	2,174	266.2	959	241.8
1979	2,596	364.4	1,104	317.3
1980	2,603	437.6	939	292.3
1981	2,611	498.6	1,113	382.6
1982	2,548	374.4	1,150	340.2
1983	3,459	489.9	1,414	370.2
1984	2,960	475.8	1,345	438.1
1985	3,017	422.2	1,470	390.8
1986	3,071	353.7	1,739	397.7
1987	3,707	350.1	1,955	426.4

[a] In 1987, 83% of corn imports were from the U.S., 16% from South Africa, and 1% from Thailand.

[b] In 1987, 99% of soybean imports were from the U.S. and 1% from Uruguay.

Source: 7.

years. In 1987, the U.S. had 99% of the market share of soybeans. U.S. exports of soybeans to Taiwan more than doubled during this 10 year period. Taiwan's imported soybeans have steadily increased from 959 thousand tons in 1978 to 1,955 thousand tons in 1985. One important question for Ohio soybean producers is whether this increasing trend continue or whether Taiwan's soybean consumption has reached the saturated level. We can not answer this question without further research on the demand for soybeans and soybean products in Taiwan. This is also true for other countries like Japan, Korea, and those in the European community.

It will not be a small task to study our existing and potential customers in foreign countries. We need to develop better data bases for this type of research. With many foreign graduate students in the Department of Agricultural Economics and Rural Sociology at The Ohio State University, we have comparative advantages. These students are very useful sources of information regarding their culture and diet habits. They can help us translate data in their languages to forms useful for American researchers, especially those at The Ohio State University.

CONCLUSIONS AND RECOMMENDATIONS

This concept paper presents (1) an analysis of the complexity of linking demand for final consumer goods to the demand for a specific agricultural commodity such as soybeans produced in Ohio, (2) the methodologies for analyzing demand for new goods and structural changes and, (3) the uses of demand models for investigating the potential for expanding new and existing markets. These concepts were illustrated using the soybean as a case study.

Our recent research has shown that the pattern of substitution among fats and oils has resulted in an increasing domestic demand for soybean oil in all end-uses. However, the future demand will depend upon consumer income, the prices of soybean oil and other fats and oils, and such factors as consumer health concerns and advertising effects.

One of the purposes of demand analyses is to detect structural changes in consumer tastes and preferences. Our research has shown that changes in demand for cooking and salad oils are related to changes in the demand for lard. This finding suggests that the health concerns about fat have made consumers shift away from the oils with high saturated fats (lard) to those with low saturated fats (such as soybean oil). However, much more work needs to be done to incorporate the health concern and the consumption perception of risk into demand analysis.

The success in generating new demand lies in the ability to produce new goods with more desirable characteristics or attributes at lower costs. Development of new uses and markets, therefore, requires information about both product characteristics and consumer perception of these characteristics.

Finally, the growing dimension of agricultural trade requires an ever increasing need to understand consumer demand in foreign markets. The patterns of consumption are likely to be different in foreign markets. It is essential to quantify foreign consumers' responses to changes in income, prices, health concerns and other promotional efforts.

Based on these analyses, I would make the following specific recommendations for implementing the concepts developed in this paper so as to enhance farm income. These recommendations include (1) to establish

a consumer panel in Ohio for collecting information about consumer perception of food product characteristics, (2) to develop a comprehensive framework for linking consumer demand to supply/demand interactions at the farmgate for major crops in Ohio, (3) to develop information and data bases and to establish research programs for analyzing foreign demand for major agricultural commodities produced in Ohio, and (4) to launch a research program for investigating the impacts of health concerns on food consumption and their implications for formulating the strategies in marketing agricultural products.

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